We claim:

1. A bioresorbable biomaterial compound comprising calcium, oxygen and phosphorous, wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å. 112

2. The biomaterial compound as claimed in claim 1, wherein a portion of the phosphorous is substituted by at least one element having an ionic radius of approximately 0.1 to 0.4Å.

3. The biomaterial compound as claimed in claim 1 ~~or 2~~, wherein said element of substitution is silicon.

4. The biomaterial compound as claimed in claim 1 ~~or 2~~, wherein said element of substitution is boron.

5. The biomaterial compound as claimed in claim 2, wherein said compound additionally comprises at least one element selected from elements having an ionic radius from approximately 0.4 to 1.1Å, wherein said additional elements substitute at sites other than phosphorous.

6. The biomaterial compound as claimed in claim 5, wherein said element has an effective charge to compensate any imbalance of charge resulting from the partial substitution of phosphorous.

7. The biomaterial compound as claimed in claim 1 ~~any one of claims 1 to 6~~ in combination with at least one calcium material selected from the group consisting of calcium hydroxyapatite, α-TCP, β-TCP, octocalcium phosphate, tetracalcium phosphate, dicalcium phosphate and calcium oxide.

8. The biomaterial compound as claimed in claim 7 wherein said compound is mixed with calcium hydroxyapatite in a ratio of approximately 20:80 to 80:20.

9. The biomaterial compound as claimed in claim 2 ~~or~~ 3 wherein said compound is defined by those peaks in the x-ray diffraction spectrum of Figure 16.

10. A biomaterial compound having the formula:



AMENDED SHEET

$(Ca_{1-w}A_w)_i[(P_{1-x-y-z}B_xC_yD_z)O_j]_2$

wherein A is selected from those elements having an ionic radius of approximately 0.4 to 1.1Å;

B, C and D are selected from those elements having an ionic radius of approximately 0.1 to 0.4Å;

w is greater than or equal to zero but less than 1;

x is greater than or equal to zero but less than 1;

y is greater than or equal to zero but less than 1;

z is greater than or equal to zero but less than 1;

x + y + z is greater than zero but less than 1;

i is greater than or equal to 2 but less than or equal to 4; and

j equals 4-δ, where δ is greater than or equal to zero but less than or equal to 1.

11. The biomaterial compound as claimed in claim 10, wherein w and δ are determined by charge compensation of the elements present in the compound.

12. The biomaterial compound as claimed in claim 10, wherein B is silicon.

13. The biomaterial compound as claimed in claim 10, wherein B is boron.

14. The biomaterial compound as claimed in claim 11, wherein A is selected from the group of elements consisting of Ce, La, Sc, Y and Zr.

15. The biomaterial compound as claimed in a~~ny one of claims 10 to 14~~ claim 10 in combination with at least one calcium phosphate material selected from the group consisting of calcium hydroxyapatite, α-TCP, β-TCP, octocalcium phosphate, tetracalcium phosphate, dicalcium phosphate and calcium oxide.

16. The biomaterial compound as claimed in ~~claims 1 or 10~~ claim 10 wherein said compound additionally comprises an additive to increase the mechanical toughness and strength of said compound.

17. The biomaterial compound as claimed in claim 16 wherein said additive is of a material comprising discrete particles of a size removable by phagocytosis by the action of macrophages.

18. The biomaterial compound as claimed in claim 17 wherein said additive

comprises micro carbon fibers.

19. The biomaterial compound as claimed in ~~claims 1 or 10,~~ Claim 10 wherein said compound is $Ca_3(P_{0.750}Si_{0.25}O_{3.875})_2$.

20. The biomaterial compound as claimed in ~~claims 1 or 10,~~ Claim 10 wherein said compound is $Ca_3(P_{0.9375}Si_{0.0625}O_{3.96875})_2$.

21. The biomaterial compound as claimed in claim ~~7 or~~ 15 wherein said combination exists as a physical mixture.

22. The biomaterial compound as claimed in claim ~~7 or~~ 15 wherein said combination exists as a solid solution.

23. The biomaterial compound as claimed in ~~claims 1 or 10~~ Claim 10 wherein said compound has a microporous structure.

24. The biomaterial compound as claimed in ~~claims 21 or 22,~~ Claim 21 wherein said combination has a microporous structure.

25. The biomaterial compound as claimed in claim 23 ~~or 24~~, wherein said microporous structure comprises particles in the size range of approximately 0.1 to 2.0 microns.

26. The biomaterial compound as claimed in ~~any one of claims 1 to 25~~ Claim 1 wherein said compound is formed as a macroporous structure comprising an open cell construction with interconnected voids having a pore size of approximately 50 to 1000 microns.

27. The biomaterial comound as claimed in claim 26 wherein said macroporous structure is formed by coating said compound onto a reticulated polymer and subsequently removing said polymer through pyrolysis.

28. The biomaterial compound as claimed in ~~any one of claims 1 to 27~~ Claim 1, wherein said compound has a nanoporous structure.

29. The biomaterial compound as claimed in claim 28 wherein said nanoporous structure comprises granules in the size range of approximately 1 to 20nm.

30. The biomaterial compound as claimed in Claim 10 ~~claims 1 or 10~~ wherein said compound has monoclinic pseudo-rhombic symmetry.

31. The biomaterial compound as claimed in Claim 10 ~~claims 1 or 10~~ wherein said compound is in the monoclinic space group $P2_1/a$.

32. The biomaterial compound as claimed in claim 1 ~~any one of claims 1 to 31,~~ wherein said compound is resorbed by the cellular activity of osteoclasts.

33. The biomaterial compound as claimed in claim 1 ~~any one of claims 1 to 31,~~ wherein said compound promotes the generation of new mineralized bone matrix by the activity of osteoblasts.

34. The biomaterial compound as claimed in Claim 1 ~~any one of claims 1 to 31~~ wherein said compound is progressively replaced with natural bone *in vivo*.

35. The biomaterial compound as claimed in Claim 10 ~~claims 1 or 10~~ wherein said compound is essentially insoluble in biological media at human physiological pH of 6.4-7.3.

36. The biomaterial compound as claimed in Claim 10 ~~claims 1, 7, 10 or 15~~ in combination with collagen.

37. The use of the biomaterial compound as claimed in Claim 1 ~~any one of claims 1 to 36~~ in orthopedic, maxillo-facial and dental applications wherein said compound exists as a fine or coarse powder, pellets, three-dimensional shaped pieces, macroporous structures, thin films and coatings.

38. The use of the biomaterial compound as claimed in Claim 1 ~~any one of claims 1 to 36~~ as a coating of thickness 0.1 to 10 microns on implantable prostheses.

39. The use of the biomaterial compound as claimed in claim 1 ~~any one of claims 1 to 36~~ in tissue engineering.

40. The use of the biomaterial compound as claimed in Claim 1 ~~any one of claims 1 to 36~~ as a carrier for pharmaceutical agents.

41. The use of the biomaterial compound as claimed in claim 40, wherein said compound acts as a slow release vehicle for pharmaceuticals at desired sites of implantation.

42. The use of the biomaterial compound as claimed in claim 41 wherein said pharmaceutical is a bone growth factor.

43. A method for substituting natural bone at sites of skeletal surgery in human and animal hosts with a biomaterial compound comprising calcium, oxygen and phosphorous wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å;

said method comprising the steps of:

implanting said biomaterial compound at the site of skeletal surgery wherein such implantation promotes the formation of new bone tissue at the interfaces between said biomaterial compound and said host, the progressive removal of said biomaterial compound primarily through osteoclast activity, and the replacement of that portion of said biomaterial compound removed by further formation of new bone tissue by osteoblast activity, such progressive removal and replacement being inherent in the natural bone remodeling process.

44. A method for repairing large segmental skeletal gaps and non-union fractures arising from trauma or surgery in human and animal hosts using a biomaterial compound comprising calcium, oxygen and phosphorous wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å;

said method comprising the steps of:

implanting said biomaterial compound at the site of the segmental skeletal gap or non-union fracture wherein such implantation promotes the formation of new bone tissue at the interfaces between said biomaterial compound and said host, the progressive removal of said biomaterial compound primarily through osteoclast activity, and the replacement of that portion of said biomaterial compound removed by further formation of new bone tissue by osteoblast activity, such progressive removal and replacement being inherent in the natural bone remodeling process.

45. A method for aiding the attachment of implantable prostheses to skeletal sites and for maintaining the long term stability of said prostheses in human and animal

hosts using a biomaterial compound comprising calcium, oxygen and phosphorous wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å;

said method comprising the steps of :

coating selected regions of an implantable prosthesis with said biomaterial compound, implanting said coated prosthesis into a skeletal site wherein such implantation promotes the formation of new bone tissue at the interfaces between said biomaterial compound and said host, the generation of a secure interfacial bond between said host bone and said coating, the subsequent progressive removal of said coating primarily through osteoclast activity such that the coating is diminished, and the replacement of that portion of said biomaterial compound removed by further formation of new bone tissue to generate a secure interfacial bond directly between said host bone and said prosthesis.

46. A method for providing tissue-engineering scaffolds for bone replacement in human or animal hosts using a biomaterial compound comprising calcium, oxygen and phosphorous wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å;

said method comprising the steps of :

forming said biomaterial compound as a macroporous structure comprising an open cell construction with interconnected voids, combining mature and/or precursor bone cells with said macroporous structure, and allowing the cells to infiltrate said structure in order to develop new mineralized matrix throughout said structure.

47. A method for delivering pharmaceutical agents to the site of skeletal surgery in human or animal hosts using a biomaterial compound comprising calcium, oxygen and phosphorous wherein at least one of said elements is substituted with an element having an ionic radius of approximately 0.1 to 1.1Å;

said method comprising the steps of :

combining a pharmaceutical agent with said biomaterial compound and applying the pharmaceutical agent combined with said biomaterial compound to a site of skeletal surgery, wherein such application results in controlled local release of said pharmaceutical agent.

48. The method of Claim 43 ~~any one of claims 43 to 47~~ wherein said biomaterial compound has the formula;

$$(Ca_{1-w}A_w)_i[(P_{1-x-y-z}B_xC_yD_z)O_j]_2$$

wherein A is selected form those elements having an ionic radius of approximately 0.4 to 1.1Å;

B, C and D are selected from those elements having an ionic radius of approximately 0.1 to 0.4Å;

w is greater than or equal to zero but less than 1;

x is greater than or equal to zero but less than 1;

y is greater than or equal to zero but less than 1;

z is greater than or equal to zero but less than 1;

x + y + z is greater than zero but less than 1;

i is greater than or equal to 2 but less than or equal to 4; and

j equals 4-δ, where δ is greater than or equal to zero but less than or equal to 1.

Claim 43

49. The method of ~~any one of claims 43 to 48~~ wherein said biomaterial compound has the formula:

$Ca_3(P_{0.75}Si_{0.25}O_{3.875})_2$.

Claim 43

50. The method of ~~any one of claims 43 to 48~~ wherein said biomaterial compound has the formula:

$Ca_3(P_{0.9375}Si_{0.0625}O_{3.96875})_2$.

Claim 43

51. The method of ~~any one of claims 43 to 50~~ wherein said biomaterial compound is combined with at least one calcium phosphate material selected from the group consisting of calcium hydroxyapatite, α-TCP, β-TCP, octocalcium phosphate, tetracalcium phosphate, dicalcium phosphate and calcium oxide.

Claim 43

52. The method of ~~any one of claims 43 to 51,~~ wherein said biomaterial compound additionally comprises an additive to increase the mechanical toughness and strength of said compound.